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DATA SHEET

TEA1099H
Speech and handsfree IC with auxiliary inputs/outputs and analog multiplexer

Product specification
Supersedes data of 1998 Jun 11
File under Integrated Circuits, IC03

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Philips Semiconductors

PHILIPS

Speech and handsfree IC with auxiliary inputs/outputs and analog multiplexer

TEA1099H

FEATURES

Line interface

- Low DC line voltage
- Voltage regulator with adjustable DC voltage
- Symmetrical high impedance inputs (70 kΩ) for dynamic, magnetic or electret microphones
- Dual Tone Multi-Frequency (DTMF) input with confidence tone on earphone and/or loudspeaker
- Receive amplifier for dynamic, magnetic or piezo-electric earpieces (with externally adjustable gain)
- AGC: Automatic Gain Control for true line loss compensation.

Supplies

- Provides a strong 3.35 V regulated supply for microcontroller or dialler
- Provides filtered power supply, optimized according to line current and compatible with external voltage or current sources
- Filtered 2.0 V power supply output for electret microphone
- Compatible with a ringer mode
- Power-Down ($\overline{PD}$) logic input for power-down.

Handsfree

- Asymmetrical high-impedance input for electret microphone
- Loudspeaker amplifier with single-ended rail-to-rail output and externally adjustable gain
- Dynamic limiter on loudspeaker amplifier to prevent distortion
- Logarithmic volume control on loudspeaker amplifier via linear potentiometer
- Duplex controller consisting of:
  - Signal and noise envelope monitors for both channels (with adjustable sensitivities and timing)
  - Decision logic (with adjustable switch-over and Idle mode timing)
  - Voice switch control (with adjustable switching range and constant sum of gain during switching).

Auxiliary interfaces

- General auxiliary output for transmit and receive purposes
- Auxiliary transmit input with high signal level capability dedicated to line transmission
- Auxiliary receive input with high signal level capability
- Integrated multiplexer for channels selection.

APPLICATIONS

- Line powered telephone sets
- Cordless telephones
- Fax machines
- Answering machines.

GENERAL DESCRIPTION

The TEA1099H is an analog bipolar circuit dedicated for telephone applications. It includes a line interface, handset (HS) microphone and earpiece amplifiers, handsfree (HF) microphone and loudspeaker amplifiers, some specific auxiliary Inputs/Outputs (I/Os) and an analog multiplexer to enable the right transmit and/or receive channels. The multiplexer is controlled by a logic circuit which decodes four logic inputs provided by a microcontroller. Thirteen different application modes have been defined and can be accessed by selecting the right logic inputs. An application mode is a special combination of transmit and receive channels required by telephone applications.

This IC can be supplied by the line and/or by the mains if available (in a cordless telephone or an answering machine for example). It provides a 3.35 V supply for a microcontroller or dialler and a 2.0 V filtered voltage supply for an electret microphone. The IC is designed to facilitate the use of the loudspeaker amplifier during ringing phase.

QUICK REFERENCE DATA

I_{line} = 15 mA; R_{SLPE} = 20 Ω; Z_{line} = 600 Ω; f = 1 kHz; T_{amb} = 25 °C; AGC pin connected to LN; $\overline{PD}$ = HIGH; HFC = LOW; AUXC = LOW; $\overline{MUTT}$ = HIGH; $\overline{MUTR}$ = HIGH; measured according to test circuits; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{line}	line current operating range	normal operation	11	–	140	mA
		with reduced performance	1	–	11	mA
V_{SLPE}	stabilized voltage between SLPE and GND (V_{ref})	I_{line} = 15 mA	3.4	3.7	4.0	V
		I_{line} = 70 mA	5.7	6.1	6.5	V
V_{BB}	regulated supply voltage for internal circuitry	I_{line} = 15 mA	2.75	3.0	3.25	V
		I_{line} = 70 mA	4.9	5.3	5.7	V
V_{DD}	regulated supply voltage on pin V_{DD}	V_{BB} > 3.35 V + 0.25 V (typ)	3.1	3.35	3.6	V
		otherwise	–	V_{BB} – 0.25	–	V
V_{ESI}	external voltage supply allowed on pin ESI		–	–	6	V
$I_{ESI(ext)}$	external current supply allowed on pin ESI		–	–	140	mA
I_{BB}	current available on pin V_{BB}	speech mode	–	11	–	mA
		handsfree mode	–	9	–	mA
$I_{BB(pd)}$	current consumption on V_{BB} during power-down phase	$\overline{PD}$ = LOW	–	460	–	µA
$G_{v(MIC-LN)}$	voltage gain from pin MIC+/MIC– to LN	V_{MIC} = 5 mV (RMS)	43.3	44.3	45.3	dB
$G_{v(IR-RECO)}$	voltage gain from pin IR (referenced to LN) to RECO	V_{IR} = 15 mV (RMS)	28.7	29.7	30.7	dB
$\Delta G_{v(QR)}$	gain voltage range between pins RECO and QR		–3	–	+15	dB
$G_{v(TXIN-TXOUT)}$	voltage gain from pin TXIN to TXOUT	V_{TXIN} = 3 mV (RMS); R_{GATX} = 30.1 kΩ	12.7	15.2	17.7	dB
$G_{v(HFTX-LN)}$	voltage gain from pin HFTX to LN	V_{HFTX} = 15 mV (RMS)	33.5	34.7	35.9	dB
$G_{v(HFRX-LSAO)}$	voltage gain from pin HFRX to LSAO	V_{HFRX} = 20 mV (RMS); R_{GALS} = 255 kΩ	25.5	28	30.5	dB
SWRA	switching range		–	40	–	dB
ΔSWRA	switching range adjustment	with R_{SWR} referenced to 365 kΩ	–40	–	+12	dB
$\Delta G_{v(trx)}$	gain control range for transmit and receive amplifiers affected by the AGC; with respect to I_{line} = 15 mA	I_{line} = 70 mA; on $G_{v(MIC-LN)}$, $G_{v(IR-RECO)}$ and $G_{v(IR-AUXO)}$	5.45	6.45	7.45	dB

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TEA1099H	QFP44	plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 × 10 × 1.75 mm	SOT307-2

BLOCK DIAGRAM

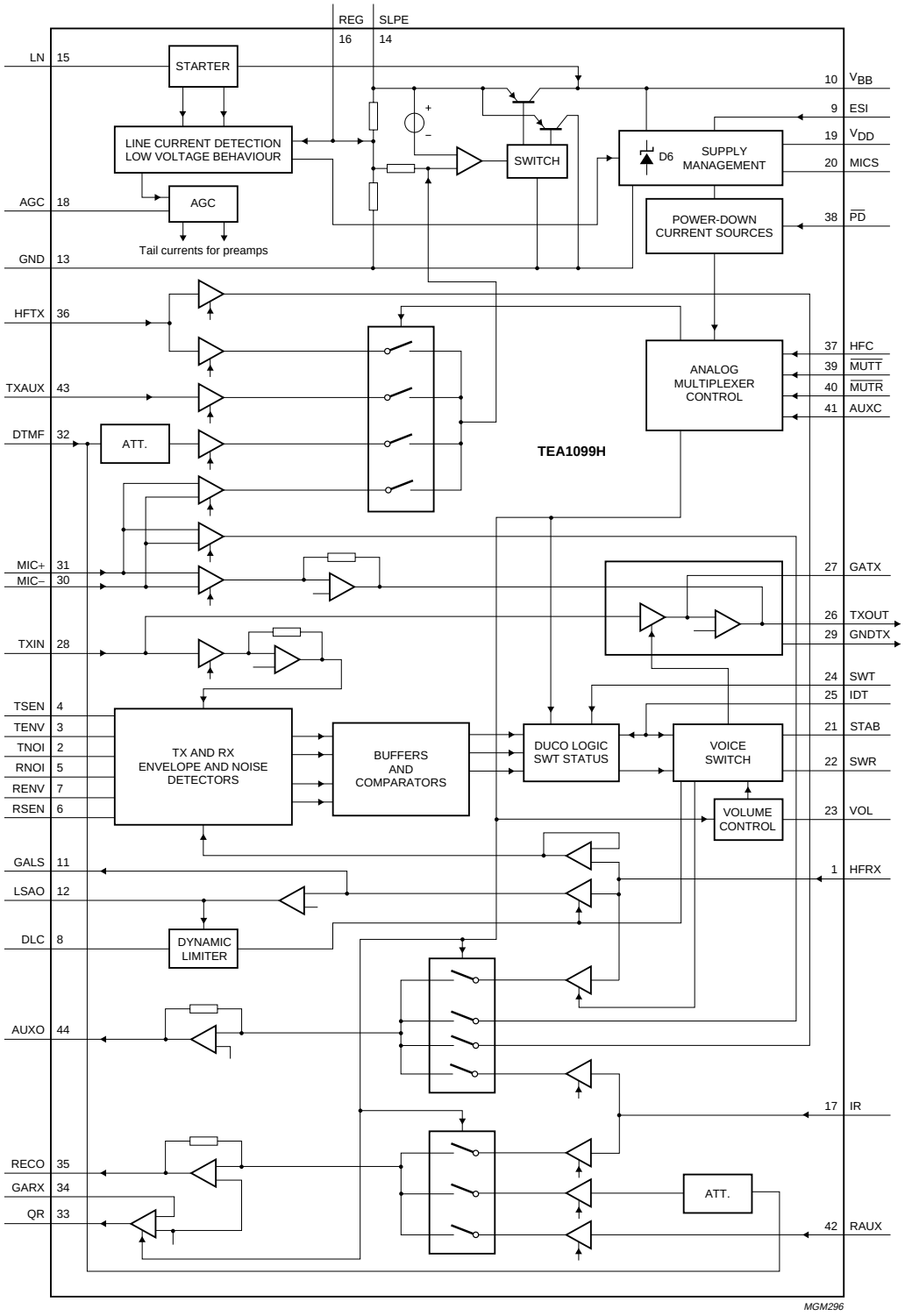


Fig.1 Block diagram.

PINNING

SYMBOL	PIN	DESCRIPTION
HFRX	1	receive input for loudspeaker amplifier or auxiliary receive amplifier
TNOI	2	transmit noise envelope timing adjustment
TENV	3	transmit signal envelope timing adjustment
TSEN	4	transmit signal envelope sensitivity adjustment
RNOI	5	receive noise envelope timing adjustment
RSEN	6	receive signal envelope sensitivity adjustment
RENV	7	receive signal envelope timing adjustment
DLC	8	dynamic limiter capacitor for the loudspeaker amplifier
ESI	9	external supply input
V_{BB}	10	stabilized supply for internal circuitry
GALS	11	loudspeaker amplifier gain adjustment
LSAO	12	loudspeaker amplifier output
GND	13	ground reference
SLPE	14	line current sense
LN	15	positive line terminal
REG	16	line voltage regulator decoupling
IR	17	receive amplifier input
AGC	18	automatic gain control/line loss compensation
V_{DD}	19	3.35 V regulated voltage supply for the microcontroller

SYMBOL	PIN	DESCRIPTION
MICS	20	microphone supply output
STAB	21	reference current adjustment
SWR	22	switching range adjustment
VOL	23	loudspeaker volume adjustment
SWT	24	switch-over timing adjustment
IDT	25	Idle mode timing adjustment
TXOUT	26	HF microphone amplifier output
GATX	27	HF microphone amplifier gain adjustment
TXIN	28	HF microphone amplifier input
GNDTX	29	ground reference for microphone amplifiers
MIC–	30	negative HS microphone amplifier input
MIC+	31	positive HS microphone amplifier input
DTMF	32	dual tone multi-frequency input
QR	33	earpiece amplifier output
GARX	34	earpiece amplifier gain adjustment
RECO	35	receive amplifier output
HFTX	36	transmit input for line amplifier or auxiliary receive amplifier
HFC	37	logic input
$\overline{PD}$	38	power-down input (active LOW)
$\overline{MUTT}$	39	logic input (active LOW)
$\overline{MUTR}$	40	logic input (active LOW)
AUXC	41	logic input
RAUX	42	auxiliary receive amplifier input
TXAUX	43	auxiliary transmit amplifier input
AUXO	44	auxiliary amplifier output

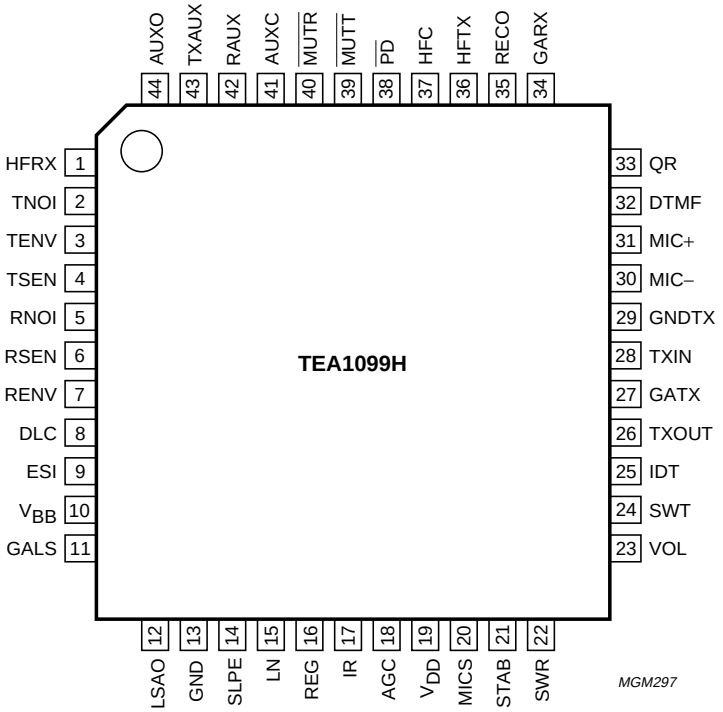


Fig.2 Pin configuration.

FUNCTIONAL DESCRIPTION

All data given in this chapter are typical values, except when otherwise specified.

Supplies

LINE INTERFACE AND INTERNAL SUPPLY (PINS LN, SLPE, REG AND V_{BB})

The supply for the TEA1099H and its peripherals is obtained from the line. The IC generates a stabilized reference voltage (V_{ref}) between pins SLPE and GND. This reference voltage is equal to 3.7 V for line currents lower than 18 mA. It than increases linearly with the line current and reaches the value of 6.1 V for line currents higher than 45 mA. For line currents below 9 mA, the internal reference voltage generating V_{ref} is automatically adjusted to a lower value. This is the so-called low voltage area and the TEA1099H has limited performances in this area (see Section “Low voltage behaviour”). This reference voltage is temperature compensated.

The voltage between pins SLPE and REG is used by the internal regulator to generate the stabilized reference voltage and is decoupled by means of a capacitor between pins LN and REG. This capacitor converted into an equivalent inductance realizes the set impedance conversion from its DC value (R_{SLPE}) to its AC value (done by an external impedance).

The IC regulates the line voltage at pin LN and it can be calculated as follows:

$$V_{LN} = V_{ref} + R_{SLPE} \times I_{SLPE}$$

$$I_{SLPE} = I_{line} - I^{x}$$

where:

I_{line} = line current

I^{x} = current consumed on pin LN (approximately a few μA)

I_{SLPE} = current flowing through the R_{SLPE} resistor

The preferred value for R_{SLPE} is 20 Ω. Changing this value will affect more than the DC characteristics; it also influences the transmit gains to the line, the gain control characteristic, the sidetone level and the maximum output swing on the line.

As can be seen from Fig.3, the internal circuitry is supplied by pin V_{BB}, which is a strong supply point combined with the line interface. The line current is flowing through the R_{SLPE} resistor and is sunk by the V_{BB} voltage stabilizer, becoming available for a loudspeaker amplifier or any peripheral IC. Its voltage is equal to 3.0 V for line currents lower than 18 mA. It than increases linearly with the line current and reaches the value of 5.3 V for line currents greater than 45 mA. It is temperature compensated. See Fig.4 for the main DC voltages.

The aim of the current switch TR1 and TR2 is to reduce distortion of large AC line signals. Current I_{SLPE} is supplied to V_{BB} via TR1 when the voltage on SLPE is greater than V_{BB} + 0.25 V. When the voltage on SLPE is lower than this value, the current I_{SLPE} is shunted to GND via TR2.

The reference voltage V_{ref} can be increased by connecting an external resistor between pins REG and SLPE. For large line currents, this increase can slightly affect some dynamic performances such as maximum signal level on the line for 2% Total Harmonic Distortion (THD). The voltage on pin V_{BB} is not affected by this external resistor.

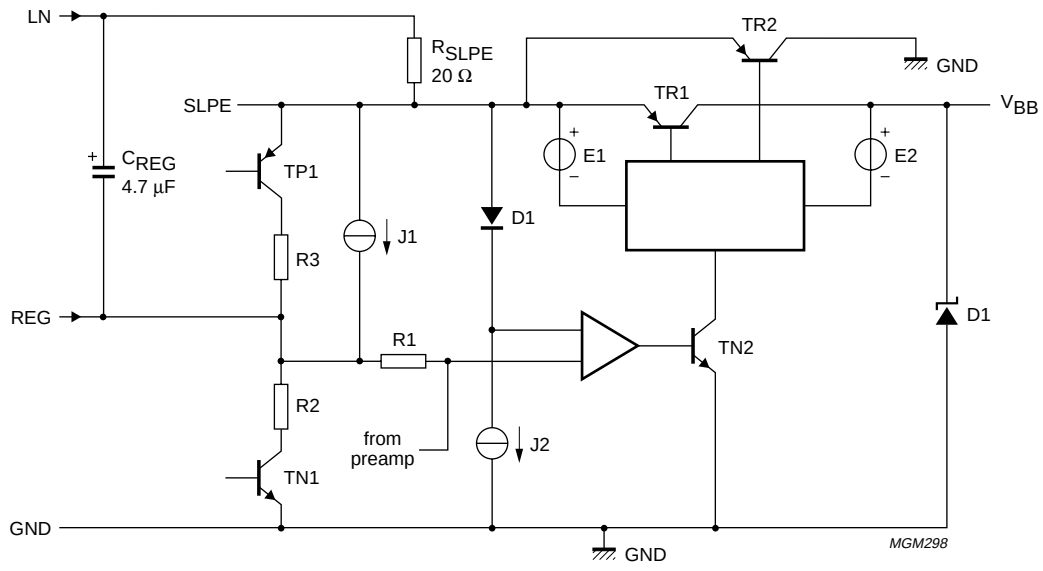


Fig.3 Line interface principle.

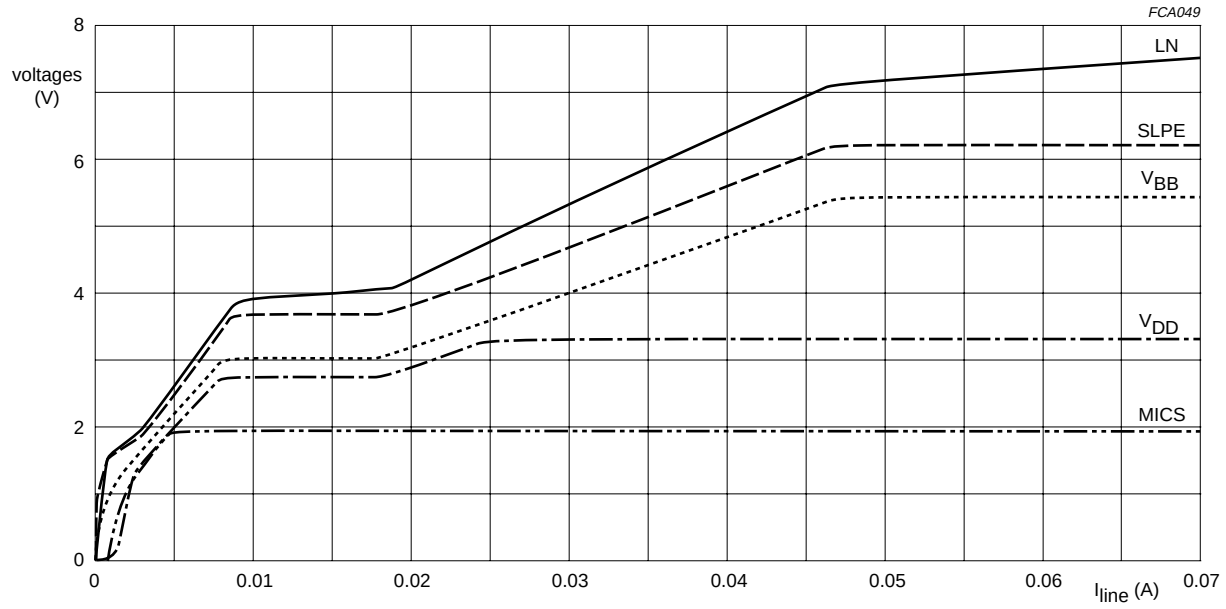


Fig.4 Main DC voltages.

EXTERNAL SUPPLY (PINS ESI AND V_{BB})

The TEA1099H can be supplied by the line as well as by external power sources (voltage or current sources) that must be connected to pin ESI.

The IC will choose which supply to use according to the voltage it can provide. A voltage supply on ESI is efficient only if its value is greater than the working voltage of the internal V_{BB} voltage stabilizer. Otherwise the IC continues to be line powered. The current consumed on this source is at least equal to the internal consumption. It increases with the voltage difference between the value forced on ESI and the working voltage of the internal stabilizer. The excess current compared to the internal consumption becomes then available for other purposes such as supplying a loudspeaker amplifier. The voltage source should not exceed 6 V. If the value of the external voltage source can be lower than the working voltage of the internal stabilizer, an external diode is required to avoid reverse current flowing into the external power supply.

In case of current source, the voltage on V_{BB} and ESI depends on the current available. It is internally limited to 6.6 V. The current source should not exceed 140 mA.

V_{DD} SUPPLY FOR MICROCONTROLLER (PIN V_{DD})

The voltage on V_{DD} supply point follows the voltage on V_{BB} with a difference typically equal to 250 mV and is internally limited to 3.35 V. This voltage is temperature compensated. This supply point can provide a current up to 3 mA typically. Its internal consumption stays low (a few 10 nA) as long as V_{DD} does not exceed 1.5 V (see Fig.5).

An external voltage can be connected on V_{DD} with limited extra consumption on V_{DD} (typically 100 μA). This voltage source should not be lower than 3.5 V or higher than 6 V.

V_{BB} and V_{DD} can supply external circuits in the limit of currents provided either from the line or from ESI, taking into account the internal current consumption.

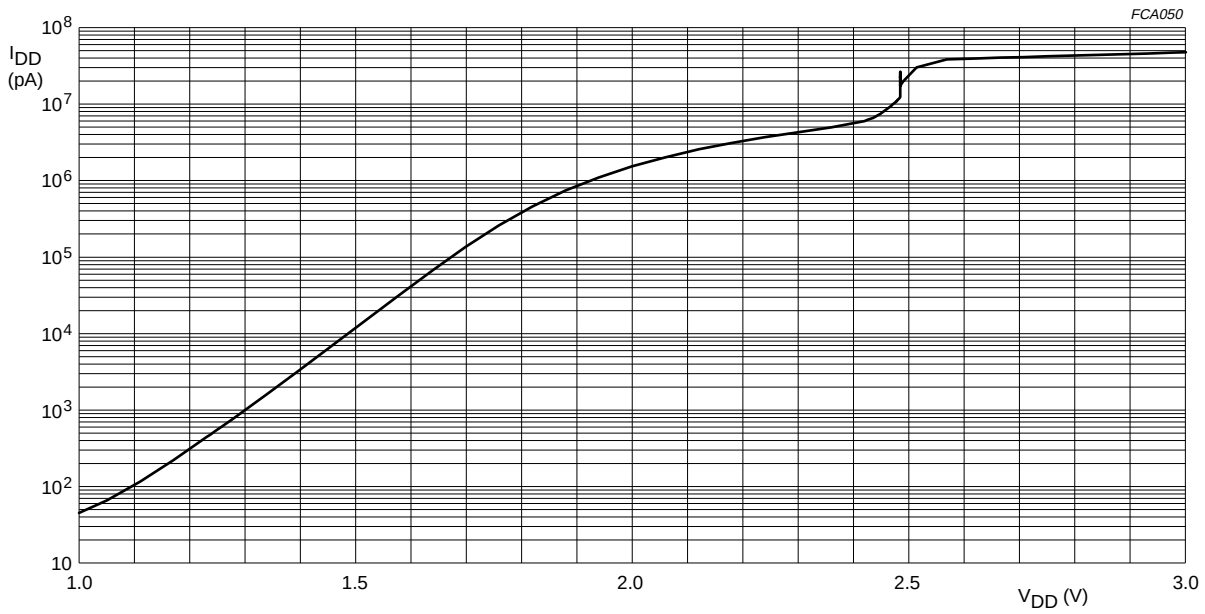


Fig.5 Current consumption on V_{DD}.

SUPPLY FOR MICROPHONE (PINS MICS AND GNDTX)

The MICS output can be used as a supply for electret microphones. Its voltage is equal to 2.0 V; it can source current up to 1 mA and has an output impedance equal to 200 Ω.

LOW VOLTAGE BEHAVIOUR

For line currents below 9 mA, the reference voltage is automatically adjusted to a lower value; the V_{BB} voltage follows the SLPE voltage with 250 mV difference.
The excess current available for other purposes than DC biasing of the IC becomes small. In this low voltage area, the IC has limited performances.

When the V_{BB} voltage reaches 2.7 V, the V_{BB} detector of the receive dynamic limiter on LSAO acts and discharges the DLC capacitor. The loudspeaker is then automatically disabled below this DC voltage.

When V_{BB} becomes lower than 2.5 V, the TEA1099H is forced into a low voltage mode whatever the levels on the logic inputs are. It is a speech mode with reduced performances only enabling the microphone channel (between the MIC inputs and LN) and the earpiece amplifier.

These two channels are able to deliver signals for line currents as small as 3 mA. The HFC input is tied to GND sinking a current typically equal to 300 μA.

POWER-DOWN MODE (PINS $\overline{PD}$ AND AUXC)

To reduce current consumption during dialling or register recall (flash), the TEA1099H is provided with a power-down input ($\overline{PD}$). When the voltage on both pins $\overline{PD}$ and AUXC is LOW, the current consumption from V_{BB} and V_{DD} is reduced to 460 μA typically. Therefore a capacitor of 470 μF on V_{BB} is sufficient to power the TEA1099H during pulse dialling or flash. The $\overline{PD}$ input has a pull-up structure, while AUXC has a pull-down structure. In this mode, the capacitor C_{REG} is internally disconnected.

RINGER MODE (PINS ESI, V_{BB}, AUXC AND $\overline{PD}$)

The TEA1099H is designed to be activated during the ringing phase. The loudspeaker amplifier can be used for the ringing signal. The IC must be powered by an external supply on ESI, while applying a HIGH level on the logic input AUXC and a LOW level on $\overline{PD}$ input. Only the HFRX input and the LSAO output are activated, in order to limit the current consumption. Some dynamic limitation is provided to prevent the LSAO output from saturation and V_{BB} from being discharged below 2.7 V.

Transmit channels (pins MIC+, MIC−, DTMF, TXAUX, HFTX and LN)

HANDSET MICROPHONE AMPLIFIER (PINS MIC+, MIC− AND LN)

The TEA1099H has symmetrical microphone inputs. The input impedance between MIC+ and MIC− is 70 kΩ (typ.). The voltage gain between pins MIC+/MIC− and LN is set to 44.3 dB. Without limitation from the output, the microphone input stage can accommodate signals up to 18 mV (RMS) at room temperature for 2% of THD. The microphone inputs are biased at one diode voltage.

Automatic gain control is provided for line loss compensation.

DTMF AMPLIFIER (PINS DTMF, LN AND RECO)

The TEA1099H has an asymmetrical DTMF input. The input impedance between DTMF and GND is 20 kΩ (typ.). The voltage gain between pins DTMF and LN is set to 25.35 dB. Without limitation from the output, the input stage can accommodate signals up to 180 mV (RMS) at room temperature for 2% of THD.

When the DTMF amplifier is enabled, dialling tones may be sent on the line. These tones can be heard in the earpiece or in the loudspeaker at a low level. This is called the confidence tone. The voltage attenuation between pins DTMF and RECO is typically equal to −16.5 dB.

The DC biasing of this input is 0 V.

The automatic gain control has no effect on these channels.

AUXILIARY TRANSMIT AMPLIFIER (PINS TXAUX AND LN)

The TEA1099H has an asymmetrical auxiliary input TXAUX. The input impedance between TXAUX and GND is 20 kΩ (typ.). The voltage gain between pins TXAUX and LN is set to 12.5 dB. Without limitation from the output, the input stage can accommodate signals up to 1.2 V (RMS) at room temperature for 2% of THD. The TXAUX input is biased at two diodes voltage.

Automatic gain control is provided for line loss compensation.

HANDSFREE TRANSMIT OUTPUT STAGE (PINS HFTX AND LN)

The TEA1099H has an asymmetrical HFTX input, which is mainly intended for use in combination with the TXOUT output. The input impedance between HFTX and GND is 20 kΩ (typ.). The voltage gain between pins HFTX and LN is set to 34.7 dB. Without limitation from the output, the input stage can accommodate signals up to 95 mV (RMS) at room temperature for 2% of THD. The HFTX input is biased at two diodes voltage.

Automatic gain control is provided for line loss compensation.

MICROPHONE MONITORING ON TXOUT (PINS MIC+, MIC− AND TXOUT)

The voltage gain between the microphone inputs MIC+/MIC− and the output TXOUT is set to 49.8 dB. This channel gives an image of the signal sent on the line while speaking in the handset microphone. Using external circuitry, this signal can be used for several purposes such as sending dynamic limitation or anti-howling in a listening-in application. The TXOUT output is biased at two diodes voltage.

The automatic gain control has no effect on these channels.

Receive channels (pins IR, RAUX, RECO, GARX and QR)

RX AMPLIFIER (PINS IR AND RECO)

The receive amplifier has one input IR which is referred to the line. The input impedance between pins IR and LN is 20 kΩ (typ.) and the DC biasing between these pins is equal to one diode voltage. The gain between pins IR (referred to LN) and RECO is typically equal to 29.7 dB. Without limitation from the output, the input stage can accommodate signals up to 50 mV (RMS) at room temperature for 2% of THD.

This receive amplifier has a rail-to-rail output RECO, which is designed for use with high ohmic (real) loads (larger than 5 kΩ). This output is biased at two diodes voltage.

Automatic gain control is provided for line loss compensation.

EARPIECE AMPLIFIER (PINS GARX AND QR)

The earpiece amplifier is an operational amplifier having its output (QR) and its inverting input (GARX) available. Its input signal comes, via a decoupling capacitor, from the receive RECO output. It is used in combination with two resistors to get the required gain or attenuation compared to the receive gain. It can be chosen between −3 and +15 dB.

Two external capacitors C_{GAR} (connected between GARX and QR) and C_{GARS} (connected between GARX and GND) ensure stability. The C_{GAR} capacitor provides a 1st-order low-pass filter. The cut-off frequency corresponds to the time constant $C_{GAR} \times R_{e2}$.
The relationship $C_{GARS} \geq 10 \times C_{GAR}$ must be fulfilled.

The earpiece amplifier has a rail-to-rail output QR, biased at two diodes voltage. It is designed for use with low ohmic (real) loads (150 Ω) or capacitive loads (100 nF in series with 100 Ω).

AUXILIARY RECEIVE AMPLIFIER (PINS RAUX AND RECO)

The auxiliary receive amplifier has an asymmetrical input RAUX; it uses the RECO output. Its input impedance between pins RAUX and GND is typically equal to 20 kΩ. The voltage gain between pins RAUX and RECO is equal to −2.4 dB. Without any limitation from the output, the input stage can accommodate signals up to 0.95 V (RMS) at room temperature for 2% of THD.

This auxiliary amplifier has a rail-to-rail output RECO, which is designed for use with high ohmic (real) loads (larger than 5 kΩ). This output is biased at two diodes voltage.

The automatic gain control has no effect on this channel.

Auxiliary amplifiers using AUXO (pins MIC+, MIC−, HFTX, IR and AUXO)

The TEA1099H has an auxiliary output AUXO, biased at two diodes voltage. This output stage is a rail-to-rail one, designed for use with high ohmic (real) loads (larger than 5 kΩ). The AUXO output amplifier is used in three different channels, two transmit channels and one receive channel.

AUXILIARY AMPLIFIERS USING THE MICROPHONE INPUTS (PINS MIC+, MIC− AND AUXO)

The auxiliary transmit amplifier using the microphone MIC+ and MIC− inputs has a gain of 25.5 dB referenced to AUXO. Without limitation from the output, the input stage can accommodate signals up to 16 mV (RMS) at room temperature for 2% of THD.

The automatic gain control has no effect on this channel.

AUXILIARY AMPLIFIERS USING HFTX (PINS HFTX AND AUXO)

The auxiliary transmit amplifier using the HFTX input has a gain of 15.2 dB referenced to AUXO.

The automatic gain control has no effect on this channel.

RX AMPLIFIER USING IR (PINS IR AND AUXO)

The auxiliary receive amplifier uses pin IR as input. The input is referred to LN and the DC biasing between these two pins is one diode voltage. The voltage gain between the input IR (referenced to LN) and the output AUXO is typically equal to 32.8 dB, which compensates typically the attenuation provided by the anti-sidetone network.

Automatic gain control is provided for line loss compensation.

AGC (pin AGC)

The TEA1099H performs automatic line loss compensation, which fits well with the true line attenuation. The automatic gain control varies the gain of some transmit and receive amplifiers in accordance with the DC line current. The control range is 6.45 dB for $G_{v(MIC-LN)}$, $G_{v(IR-RECO)}$ and $G_{v(IR-AUXO)}$ and 6.8 dB for the other affected channels, which corresponds approximately to a line length of 5.5 km for a 0.5 mm twisted-pair copper cable.

To enable this gain control, the AGC pin must be shorted to pin LN. The start current for compensation corresponds to a line current equal to typically 23 mA and the stop current to 57 mA. The start current can be increased by connecting an external resistor between pins AGC and LN. It can be increased up to 40 mA (using a resistor typically equal to 80 kΩ). The start and stop current will be maintained in a ratio equal to 2.5. By leaving the AGC pin open-circuit, the gain control is disabled and no line loss compensation is performed.

Handsfree application

As can be seen from Fig.3, a loop is formed via the sidetone network in the line interface part and the acoustic coupling between loudspeaker and microphone of the handsfree part. When this loop gain is greater than 1, howling occurs. In a full duplex application, this would be the case. The loop-gain has to be much lower than 1 and therefore has to be decreased to avoid howling. This is achieved by the duplex controller. The duplex controller of the TEA1099H detects which channel has the 'largest' signal and then controls the gain of the microphone amplifier and the loudspeaker amplifier so that the sum of the gains remains constant.

As a result, the circuit in this handsfree application can be in three stable modes:

1. Transmit mode (TX mode).

   The gain of the microphone amplifier is at its maximum and the gain of the loudspeaker amplifier is at its minimum.
2. Receive mode (RX mode).

   The gain of the loudspeaker amplifier is at its maximum and the gain of the microphone amplifier is at its minimum.
3. Idle mode.

   The gain of the amplifiers is halfway between their maximum and minimum value.

The difference between the maximum gain and minimum gain is called the switching range.

HANDSFREE MICROPHONE CHANNEL: PINS TXIN, GATX, TXOUT AND GNDTX (see Fig.7)

The TEA1099H has an asymmetrical handsfree microphone input TXIN with an input resistance of 20 kΩ. The DC biasing of the input is 0 V. The gain of the input stage varies according to the mode of the TEA1099H. In the transmit mode, the gain is at its maximum; in the receive mode, it is at its minimum and in the Idle mode it is halfway between maximum and minimum.

Switch-over from one mode to the other is smooth and click-free. The output TXOUT is biased at two diodes voltage and has a current capability equal to 20 μA (RMS). In the transmit mode, the overall gain of the microphone amplifier (from pins TXIN to TXOUT) can be adjusted from 0 up to 31 dB to suit specific application requirements. The gain is proportional to the value of R_{GATX} and equals 15.2 dB with R_{GATX} = 30.1 kΩ. Without limitation from the output, the microphone input stage can accommodate signals up to 18 mV (RMS) at room temperature for 2% of THD.

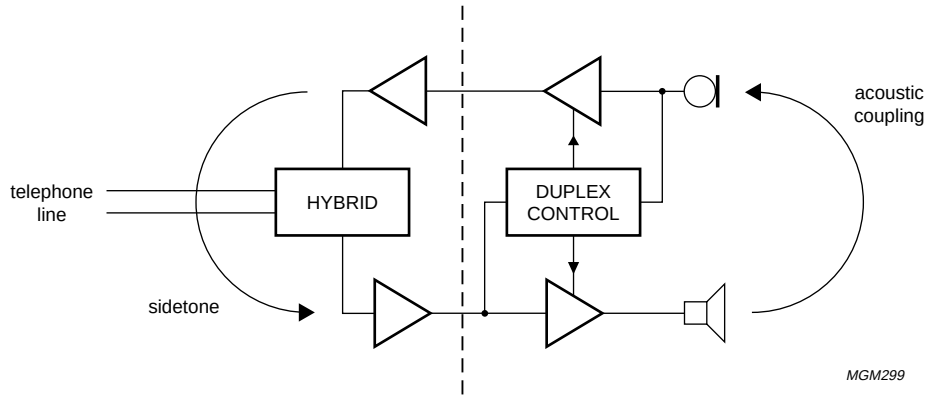


Fig.6 Handsfree telephone set principles.

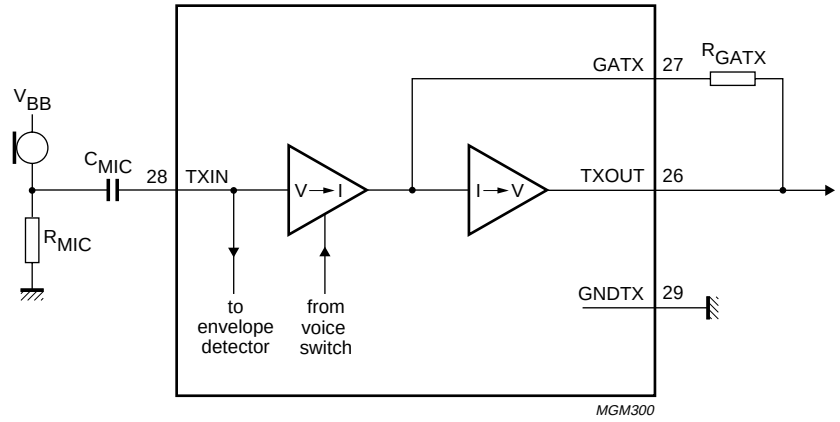


Fig.7 Handsfree microphone channel.

LOUDSPEAKER CHANNEL

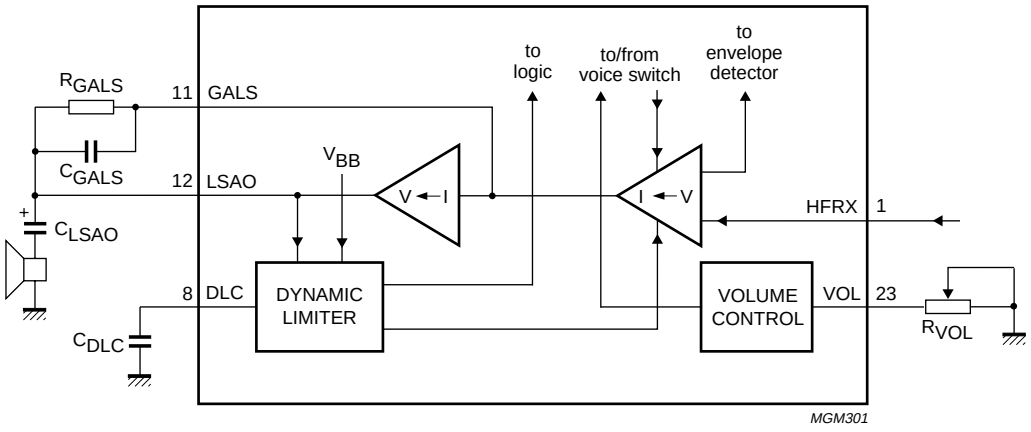


Fig.8 Loudspeaker channel.

Loudspeaker amplifier: pins HFRX, GALS and LSAO

The TEA1099H has an asymmetrical input for the loudspeaker amplifier with an input resistance of 20 kΩ between pins HFRX and GND. It is biased at two diodes voltage. Without limitation from the output, the input stage can accommodate signals up to 580 mV (RMS) at room temperature for 2% of THD.

The gain of the input stage varies according to the mode of the TEA1099H. In the receive mode, the gain is at its maximum; in the transmit mode, it is at its minimum and in the Idle mode, it is halfway between maximum and minimum. Switch-over from one mode to the other is smooth and click-free. The rail-to-rail output stage is designed to power a loudspeaker connected as a single-ended load (between pins LSAO and GND).

In the receive mode, the overall gain of the loudspeaker amplifier can be adjusted from 0 up to 35 dB to suit specific application requirements. The gain from HFRX to LSAO is proportional to the value of R_{GALS} and equals 28 dB with R_{GALS} = 255 kΩ. A capacitor connected in parallel with R_{GALS} is recommended and provides a 1st-order low-pass filter.

Volume control: pin VOL

The loudspeaker amplifier gain can be adjusted with the potentiometer R_{VOL}. A linear potentiometer can be used to obtain logarithmic control of the gain at the loudspeaker amplifier. Each 1.9 kΩ increase of R_{VOL} results in a gain loss of 3 dB. The maximum gain reduction with the volume control is internally limited to the switching range.

Dynamic limiter: pin DLC

The dynamic limiter of the TEA1099H prevents clipping of the loudspeaker output stage and protects the operation of the circuit when the supply voltage at V_{BB} falls below 2.7 V.

Hard clipping of the loudspeaker output stage is prevented by rapidly reducing the gain when the output stage starts to saturate. The time in which gain reduction is effected (clipping attack time) is approximately a few milliseconds. The circuit stays in the reduced gain mode until the peaks of the loudspeaker signal no longer cause saturation. The gain of the loudspeaker amplifier then returns to its normal value within the clipping release time (typically 250 ms). Both attack and release times are proportional to the value of the capacitor C_{DLC}. The total harmonic distortion of the loudspeaker output stage, in reduced gain mode, stays below 2% up to 10 dB (minimum) of input voltage overdrive [providing V_{HFRX} is below 580 mV (RMS)].

When the supply voltage drops below an internal threshold voltage of 2.7 V, the gain of the loudspeaker amplifier is rapidly reduced (approximately 1 ms). When the supply voltage exceeds 2.7 V, the gain of the loudspeaker amplifier is increased again.

By forcing a level lower than 0.2 V on pin DLC, the loudspeaker amplifier is muted and the TEA1099H is automatically forced into the transmit mode.

RX amplifier using AUXO

In some cordless applications, the handset may be used to perform handsfree function (instead of the base). As the TEA1099H is in the base and the active loudspeaker is in the handset, a second receive output is required. The amplifier using HFRX as an input and AUXO as an output will be used for communication with the RF IC, sending information to the handset. It will be controlled by the duplex controller in the same way as the loudspeaker amplifier.

The voltage gain between pins HFRX and AUXO is equal to 3.7 dB. The amplifier can manage the same input signal as the loudspeaker amplifier. It has a rail-to-rail output, biased by two diodes, designed for use with high ohmic (real) loads (larger than 5 kΩ). The volume control and the dynamic limiter are not active on this channel.

DUPLEX CONTROLLER

Signal and noise envelope detectors: pins TSEN, TENV, TNOI, RSEN, RENV and RNOI

The signal envelopes are used to monitor the signal level strength in both channels. The noise envelopes are used to monitor background noise in both channels. The signal and noise envelopes provide inputs for the decision logic. The signal and noise envelope detectors are shown in Fig.9.

For the transmit channel, the input signal at TXIN is 40 dB amplified to TSEN. For the receive channel, the input signal at HFRX is 0 dB amplified to RSEN. The signals from TSEN and RSEN are logarithmically compressed and buffered to TENV and RENV respectively. The sensitivity of the envelope detectors is set with R_{TSEN} and R_{RSEN}. The capacitors connected in series with the two resistors block any DC component and form a 1st-order high-pass filter. In the basic application (see Fig.16) it is assumed that V_{TXIN} = 1 mV (RMS) and V_{HFRX} = 100 mV (RMS) nominal and both R_{TSEN} and R_{RSEN} have a value of 10 kΩ. With the value of C_{TSEN} and C_{RSEN} at 100 nF, the cut-off frequency is at 160 Hz.

The buffer amplifiers which apply the compressed signals to TENV and RENV have a maximum source current of 120 μA and a maximum sink current of 1 μA. Together with the capacitor C_{TENV} and C_{RENV}, the timing of the signal envelope monitors can be set. In the basic application, the value of both capacitors is 470 nF. Because of the logarithmic compression, each 6 dB signal increase means 18 mV increase of the voltage on the envelopes TENV or RENV at room temperature. Thus, timings can be expressed in dB/ms. At room temperature, the 120 μA sourced current corresponds to a maximum rise-slope of the signal envelope of 85 dB/ms. This is sufficient to track normal speech signals. The 1 μA current sunk by TENV or RENV corresponds to a maximum fall-slope of 0.7 dB/ms. This is sufficient for a smooth envelope and also eliminates the effect of echoes on switching behaviour.

To determine the noise level, the signals on TENV and RENV are buffered to TNOI and RNOI. These buffers have a maximum source current of 1 μA and a maximum sink current of 120 μA. Together with the capacitors C_{TNOI} and C_{RNOI}, the timings can be set. In the basic application (see Fig.16) the value of both capacitors is 4.7 μF. At room temperature, the 1 μA sourced current corresponds to a maximum rise-slope of the noise envelope of approximately 0.07 dB/ms.

This is small enough to track background noise and not to be influenced by speech bursts. The 120 μA current that is sunk corresponds to a maximum fall-slope of approximately 8.5 dB/ms. However, during the decrease of the signal envelope, the noise envelope tracks the signal envelope so it will never fall faster than approximately 0.7 dB/ms. The behaviour of the signal envelope and noise envelope monitors is illustrated in Fig.10.

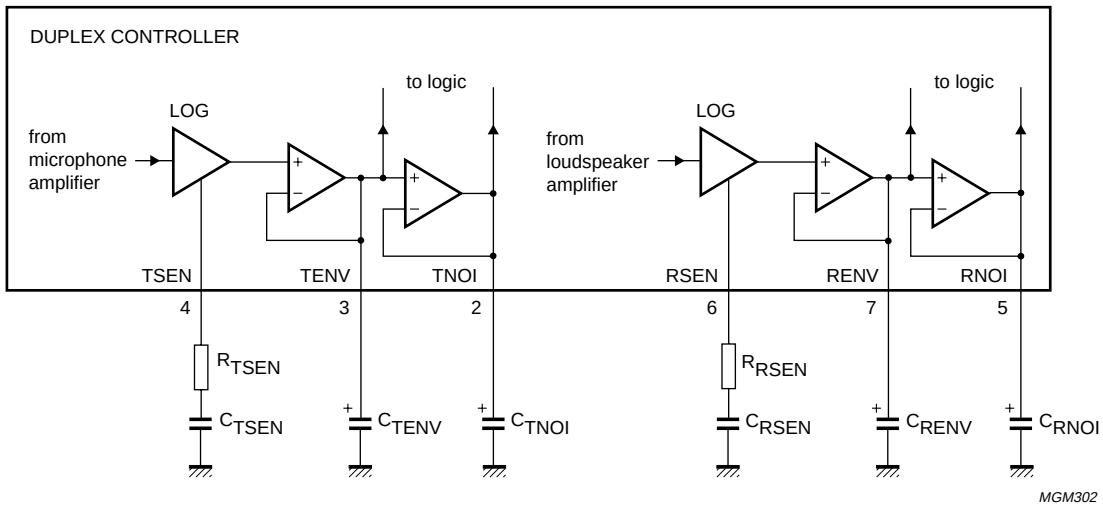


Fig.9 Signal and noise envelope detectors.

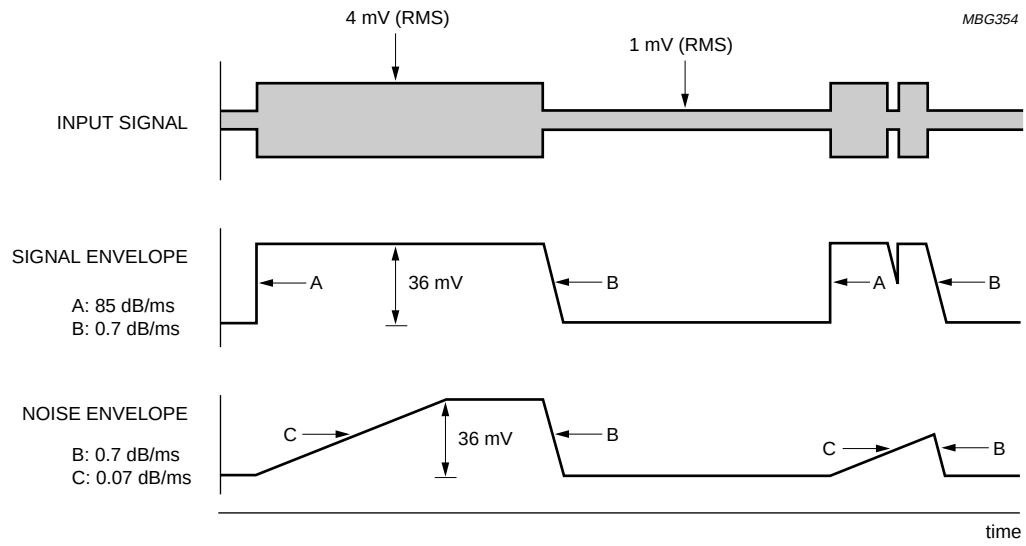
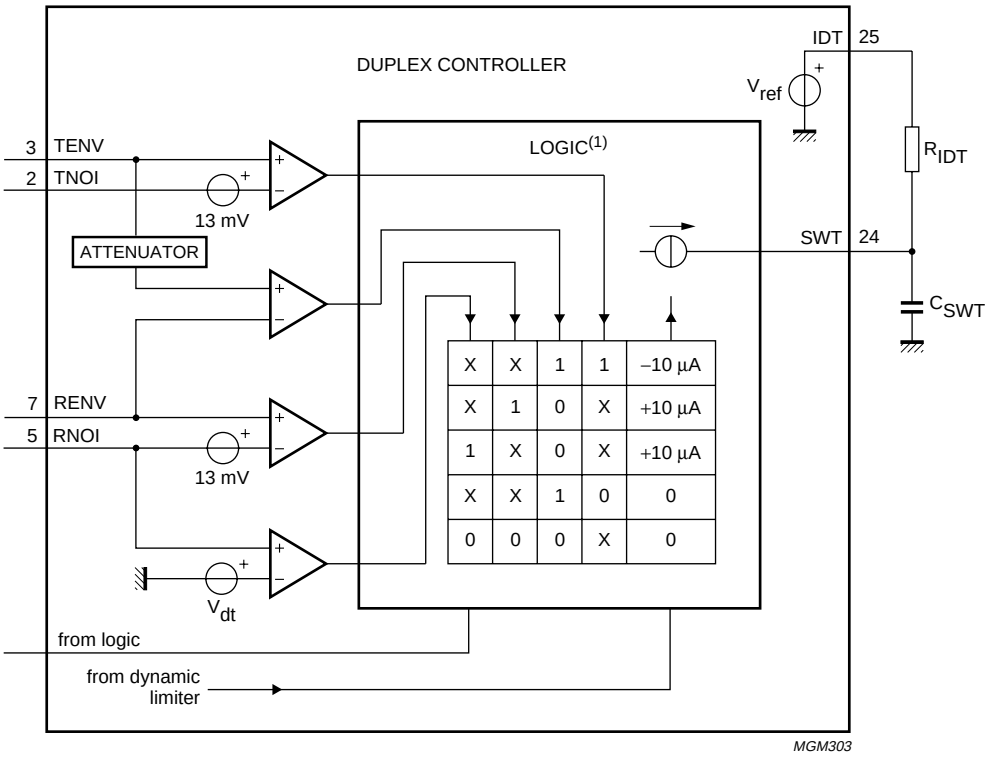


Fig.10 Signal and noise envelope waveforms.

Decision logic: pins IDT and SWT



X	X	1	1	–10 µA
X	1	0	X	+10 µA
1	X	0	X	+10 µA
X	X	1	0	0
0	0	0	X	0

(1) When V_{DLC} < 0.2 V, –10 µA is forced.

Fig.11 Decision logic.

The TEA1099H selects its mode of operation (transmit, receive or Idle mode) by comparing the signal and the noise envelopes of both channels. This is executed by the decision logic. The resulting voltage on pin SWT is the input for the voice switch.

To facilitate the distinction between signal and noise, the signal is considered as speech when its envelope is more than 4.3 dB above the noise envelope. At room temperature, this is equal to a voltage difference $V_{ENV} - V_{NOI} = 13$ mV. This so called speech/noise threshold is implemented in both channels.

The signal on pin TXIN contains both the speech and the input signal from the loudspeaker (acoustic coupling). When receiving, the contribution from the loudspeaker overrules the speech. As a result, the signal envelope on TENV is formed mainly by the loudspeaker signal. To correct this, an attenuator is connected between TENV and the TENV/RENV comparator. Its attenuation equals that applied to the microphone amplifier.

When a dial tone is present on the line, without monitoring, the tone would be recognized as noise because it is a signal with a constant amplitude. This would cause the TEA1099H to go into the Idle mode and the user of the set would hear the dial tone fade away. To prevent this, a dial tone detector is incorporated which, in standard applications, does not consider input signals between HFRX and GND as noise when they have a level greater than 25 mV (RMS). This level is proportional to R_{RSEN}.

In the same way, a transmit detector is integrated which, in standard applications, does not consider input signals between TXIN and GNDTX as noise when they have a level greater than 0.75 mV (RMS). This level is proportional to R_{TSEN}.

The output of the decision logic is a current source (see Fig.11). The logic table gives the relationship between the inputs and the value of the current source. It can charge or discharge the capacitor C_{SWT} with a current of 10 μA (switch-over). If the current is zero, the voltage on SWT becomes equal to the voltage on IDT via the high-ohmic resistor R_{IDT} (idling). The resulting voltage difference between SWT and IDT determines the mode of the TEA1099H and can vary between −400 and +400 mV (see Table 1).

The switch-over timing can be set with C_{SWT}, the Idle mode timing with C_{SWT} and R_{IDT}. In the basic application given in Fig.16, C_{SWT} is 220 nF and R_{IDT} is 2.2 MΩ. This enables a switch-over time from transmit to receive mode or vice-versa of approximately 13 ms (580 mV swing on SWT).

The switch-over time from Idle mode to transmit mode or receive mode is approximately 4 ms (180 mV swing on SWT).

The switch-over time, from receive mode or transmit mode to Idle mode is equal to $4 \times R_{IDT}C_{SWT}$ and is approximately 2 seconds (Idle mode time).

The input DLC overrules the decision logic. When the voltage on pin DLC goes lower than 0.2 V, the capacitor C_{SWT} is discharged with 10 μA thus resulting in the transmit mode.

Table 1 Modes of TEA1099H

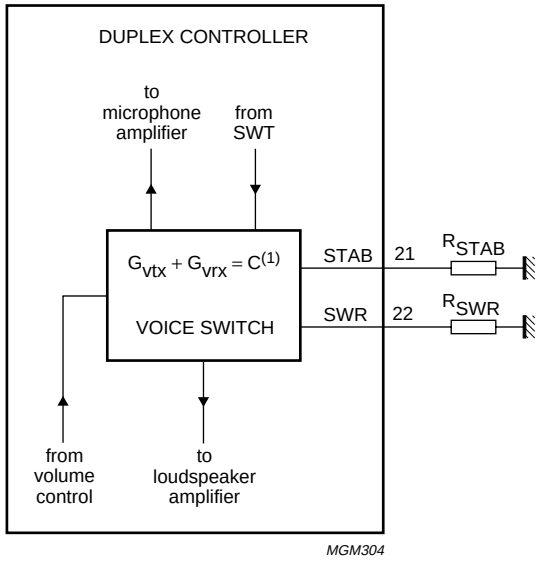
$V_{SWT} - V_{IDT}$ (mV)	MODE
<–180	transmit mode
0	Idle mode
>180	receive mode

Voice-switch: pins STAB and SWR

A diagram of the voice-switch is illustrated in Fig.12. With the voltage on SWT, the TEA1099H voice-switch regulates the gains of the transmit and the receive channels so that the sum of both is kept constant.

In the transmit mode, the gain of the microphone amplifier is at its maximum and the gain of the loudspeaker amplifier is at its minimum. In the receive mode, the opposite applies. In the Idle mode, both microphone and loudspeaker amplifier gains are halfway. The difference between maximum and minimum is the so called switching range. This range is determined by the ratio of R_{SWR} and R_{STAB} and is adjustable between 0 and 52 dB. R_{STAB} should be 3.65 kΩ and sets an internally used reference current. In the basic application diagram given in Fig.16, R_{SWR} is 365 kΩ which results in a switching range of 40 dB. The switch-over behaviour is illustrated in Fig.13.

In the receive mode, the gain of the loudspeaker amplifier can be reduced using the volume control. Since the voice switch keeps the sum of the gains constant, the gain of the microphone amplifier is increased at the same time (see dashed curves in Fig.13). In the transmit mode, however, the volume control has no influence on the gain of the microphone amplifier or the gain of the loudspeaker amplifier. Consequently, the switching range is reduced when the volume is reduced. At maximum reduction of volume, the switching range becomes 0 dB.



(1) C = constant.

Fig.12 Voice switch.

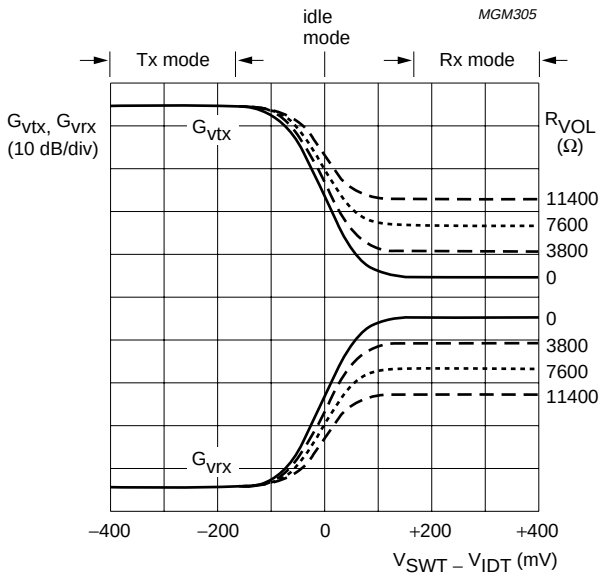


Fig.13 Switch-over behaviour.

Logic inputs

Table 2 Selection of transmit and receive channels for 13 different application modes

LOGIC INPUTS					FEATURES	APPLICATION EXAMPLES
$\overline{PD}$	HFC	$\overline{MUTT}$	$\overline{MUTR}$	AUXC		
0	X	X	X	1	HFRX to LSAO	ringer mode
0	X	X	X	0		flash, DC dialling
1	0	0	0	0	DTMF to LN; DTMF to RECO; QR and MICS are active	DTMF dialling in handset mode
1	0	0	1	0	MIC to AUXO; RAUX to RECO; QR and MICS are active	cordless intercom with corded handset
1	0	1	1	0	MICS to LN; IR to RECO; IR to AUXO MIC to TXOUT; QR and MICS are active	handset conversation
1	0	1	0	1	TXAUX to LN; IR to AUXO	conversation using auxiliary I/O such as cordless conversation
1	1	1	1	1	TXIN to TXOUT; HFTX to LN; IR to RECO; HFRX to AUXO	cordless: HF mode in cordless handset
1	1	0	1	1	RAUX to RECO; HFRX to LSAO	listening on the loudspeaker
1	1	0	0	1	TXAUX to LN; IR to AUXO; RAUX to RECO; HFRX to LSAO	answering machine: play and record messages; listen to the recorded message on the loudspeaker
1	1	0	0	0	DTMF to LN; DTMF to RECO; HFRX to LSAO; QR and MICS are active	DTMF dialling in HF/GL modes
1	1	1	0	1	TXAUX to LN; IR to AUXO; IR to RECO; HFRX to LSAO	answering machine: play and record messages while listening on the loudspeaker
1	1	0	1	0	TXIN to TXOUT; HFTX to AUXO; RAUX to RECO; HFRX to LSAO; MICS is active	cordless intercom with base
1	1	1	1	0	TXIN to TXOUT; HFTX to LN; IR to RECO; IR to AUXO; HFRX to LSAO; MICS is active	HF conversation mode
1	1	1	0	0	MIC to LN; IR to RECO; IR to AUXO; HFRX to LSAO; MIC to TXOUT; QR; MICS is active	handset conversation with group-listening

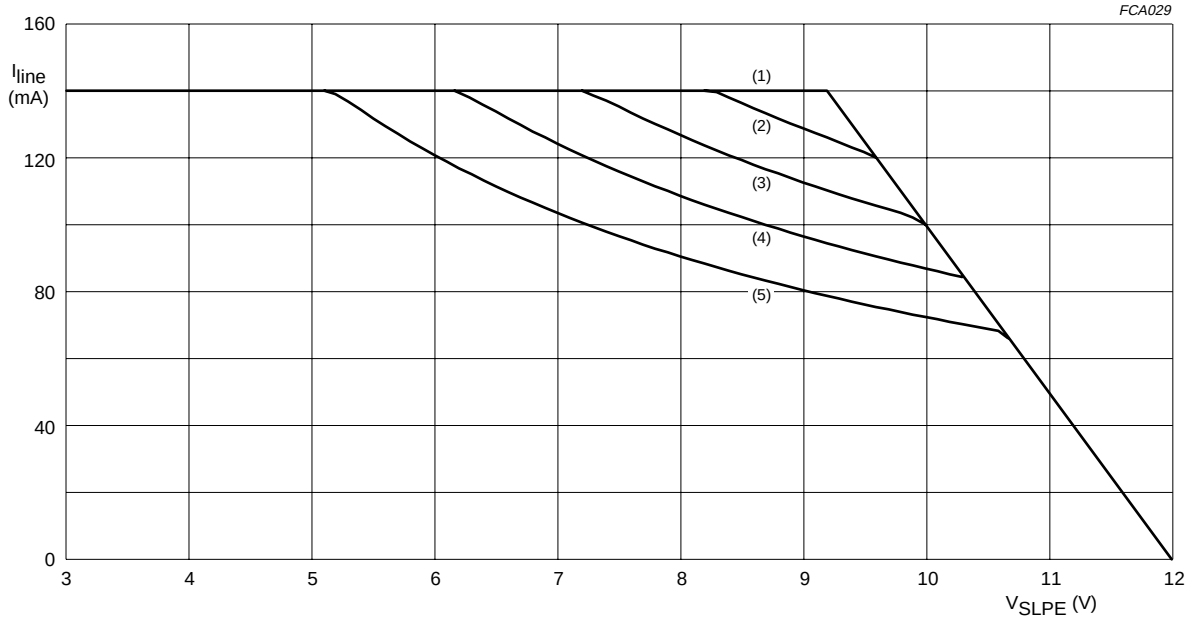
LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134); all DC levels are referenced to GND.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{LN}	positive continuous line voltage		–0.4	+12	V
	repetitive line voltage during switch-on or line interruption		–0.4	+13.2	V
V_{ESI}	positive continuous voltage on pin ESI		–0.4	+6	V
$I_{i(ESI)}$	input current at pin ESI		–	140	mA
$V_{n(max)}$	maximum voltage				
	on pins REG, SLPE, IR and AGC		–0.4	V_{LN} + 0.4	V
	on all other pins except V_{DD}		–0.4	V_{BB} + 0.4	V
$I_{line(max)}$	maximum line current		–	140	mA
P_{tot}	total power dissipation	T_{amb} = 75 °C	–	720	mW
T_{stg}	IC storage temperature		–40	+125	°C
T_{amb}	operating ambient temperature		–25	+75	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	63	K/W



LINE	T_{amb} (°C)	P_{tot} (mW)
(1)	35	1304
(2)	45	1158
(3)	55	1012
(4)	65	866
(5)	75	720

Fig.14 Safe operating area.

CHARACTERISTICS

I_{line} = 15 mA; R_{SLPE} = 20 Ω; Z_{line} = 600 Ω; f = 1 kHz; T_{amb} = 25 °C; AGC pin connected to LN; $\overline{PD}$ = HIGH; HFC = LOW; AUXC = LOW; $\overline{MUTT}$ = HIGH; $\overline{MUTR}$ = HIGH; measured according to test circuits; all DC levels are referenced to GND; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supplies						
LINE INTERFACE AND INTERNAL SUPPLY (PINS LN, SLPE, REG AND V_{BB})						
V_{SLPE}	stabilized voltage between SLPE and GND (V_{ref})	I_{line} = 15 mA	3.4	3.7	4	V
		I_{line} = 70 mA	5.7	6.1	6.5	V
V_{BB}	regulated supply voltage for internal circuitry	I_{line} = 15 mA	2.75	3.0	3.25	V
		I_{line} = 70 mA	4.9	5.3	5.7	V
I_{line}	line current for voltage increase	start current	–	18	–	mA
		stop current	–	45	–	mA
$\Delta V_{SLPE(T)}$	stabilized voltage variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±60	–	mV
$\Delta V_{BB(T)}$	regulated voltage variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±30	–	mV
I_{BB}	current available on pin V_{BB}	speech mode	–	11	–	mA
		handsfree mode	–	9	–	mA
V_{LN}	line voltage	I_{line} = 1 mA	–	1.55	–	V
		I_{line} = 4 mA	–	2.35	–	V
		I_{line} = 15 mA	3.7	4.0	4.3	V
		I_{line} = 140 mA	–	8.9	9.5	V
EXTERNAL SUPPLY (PIN ESI)						
V_{ESI}	external voltage supply allowed on pin ESI		–	–	6	V
	voltage on pin ESI when supplied by a current source	I_{ESI} = 140 mA except in Power-down mode	–	6.6	–	V
$I_{i(ESI)}$	input current on pin ESI	V_{ESI} = 3.5 V	–	3.1	–	mA
$I_{ESI(ext)}$	external current supply allowed on pin ESI		–	–	140	mA
SUPPLY FOR PERIPHERALS (PIN V_{DD})						
V_{DD}	regulated supply voltage on V_{DD}	V_{BB} > 3.35 V + 0.25 V (typ.)	3.1	3.35	3.6	V
		otherwise	–	V_{BB} – 0.25	–	V
$\Delta V_{DD(T)}$	regulated voltage variation with temperature referenced to 25 °C	T_{amb} = –25 to + 75 °C; V_{BB} > 3.35 V + 0.25 V (typ.)	–	±30	–	mV
I_{DD}	current consumption on V_{DD} (capacitor disconnected)	in trickle mode; I_{line} = 0 mA; V_{DD} = 1.5 V; V_{BB} discharging	–	15	150	nA
		V_{DD} > 3.35 V	60	100	–	µA
$I_{DD(o)}$	current available for peripherals	V_{DD} = 3.35 V	–	–	–3	mA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
SUPPLY FOR MICROPHONE (PIN MICS)						
V_{MICS}	supply voltage for a microphone	I_{MICS} = 0 mA	–	2.0	–	V
I_{MICS}	current available on MICS		–	–	–1	mA
POWER-DOWN INPUT (PIN $\overline{PD}$)						
V_{IL}	LOW-level input voltage		–0.4	–	0.3	V
V_{IH}	HIGH-level input voltage		1.8	–	V_{BB} + 0.4	V
$I_{i(pd)}$	input current		–	–3	–6	µA
$I_{BB(pd)}$	current consumption on V_{BB} during power-down phase	$\overline{PD}$ = LOW; AUXC = LOW	–	460	–	µA
RINGER MODE (PINS $\overline{PD}$, AUXC, HFRX AND LSAO)						
$I_{i(ESI)}$	input current on pin ESI	$\overline{PD}$ = LOW; AUXC = HIGH; V_{ESI} = 3.5 V	–	3.1	–	mA
$G_{v(HFRX-LSAO)}$	voltage gain from pin HFRX to LSAO	$\overline{PD}$ = LOW; AUXC = HIGH; V_{ESI} = 3.5 V; V_{HFRX} = 20 mV (RMS); R_{GALS} = 255 kΩ	–	28	–	dB
Preamplifier inputs (pins MIC+, MIC–, IR, DTMF, TXIN, HFTX, HFRX, TXAUX and RAUX)						
$\lvert Z_{i(MIC)} \rvert$	input impedance					
	differential between pins MIC+ and MIC–		–	70	–	kΩ
	single-ended between pins MIC+/MIC– and GNDTX		–	35	–	kΩ
$\lvert Z_{i(IR)} \rvert$	input impedance between pins IR and LN		–	20	–	kΩ
$\lvert Z_{i(DTMF)} \rvert$	input impedance between pins DTMF and GND		–	20	–	kΩ
$\lvert Z_{i(TXIN)} \rvert$	input impedance between pins TXIN and GNDTX		–	20	–	kΩ
$\lvert Z_{i(HFTX)} \rvert$	input impedance between pins HFTX and GND		–	20	–	kΩ
$\lvert Z_{i(HFRX)} \rvert$	input impedance between pins HFRX and GND		–	20	–	kΩ
$\lvert Z_{i(TXAUX)} \rvert$	input impedance between pins TXAUX and GND		–	20	–	kΩ
$\lvert Z_{i(RAUX)} \rvert$	input impedance between pins RAUX and GND		–	20	–	kΩ

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
TX amplifiers						
TX HANDSET MICROPHONE AMPLIFIER (PINS MIC+, MIC– AND LN); note 1						
$G_{v(MIC-LN)}$	voltage gain from pin MIC+/MIC– to LN	V_{MIC} = 5 mV (RMS)	43.3	44.3	45.3	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.25	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.25	–	dB
CMRR	common mode rejection ratio		–	80	–	dB
THD	total harmonic distortion at LN	V_{LN} = 1.4 V (RMS)	–	–	2	%
		I_{line} = 4 mA; V_{LN} = 0.12 V (RMS)	–	–	10	%
$V_{no(LN)}$	noise output voltage at pin LN; pins MIC+/MIC– shorted through 200 Ω	psophometrically weighted (p53 curve)	–	–77.5	–	dBmp
$\Delta G_{v(mute)}$	gain reduction if not activated	$\overline{HFC}$ = LOW; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = LOW; AUXC = LOW;	60	80	–	dB
DTMF AMPLIFIER (PINS DTMF, LN AND RECO); note 1						
$G_{v(DTMF-LN)}$	voltage gain from pin DTMF to LN	V_{DTMF} = 50 mV (RMS)	24.35	25.35	26.35	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.25	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.25	–	dB
$\Delta G_{v(mute)}$	gain reduction if not activated	$\overline{HFC}$ = LOW; $\overline{MUTT}$ = HIGH; $\overline{MUTR}$ = HIGH; AUXC = LOW	60	80	–	dB
$G_{v(DTMF-RECO)}$	voltage gain from pin DTMF to RECO	V_{DTMF} = 50 mV (RMS)	–	–16.5	–	dB
TX AUXILIARY AMPLIFIER USING TXAUX (PINS TXAUX AND LN); note 1						
$G_{v(TXAUX-LN)}$	voltage gain from pin TXAUX to LN	V_{TXAUX} = 0.1 V (RMS)	11.5	12.5	13.5	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.25	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.25	–	dB
THD	total harmonic distortion at LN	V_{LN} = 1.4 V (RMS)	–	–	2	%
$V_{TXAUX(rms)}$	maximum input voltage at TXAUX (RMS value)	I_{line} = 70 mA; THD = 2%	–	1.2	–	V
$V_{no(LN)}$	noise output voltage at pin LN; pin TXAUX shorted to GND through 200 Ω in series with 10 μF	psophometrically weighted (p53 curve)	–	–80.5	–	dBmp

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$\Delta G_{v(mute)}$	gain reduction if not activated	HFC = LOW; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = LOW; AUXC = LOW	60	80	–	dB
TX AMPLIFIER USING HFTX (PINS HFTX AND LN); note 1						
$G_{v(HFTX-LN)}$	voltage gain from pin HFTX to LN	V_{HFTX} = 15 mV (RMS)	33.5	34.7	35.9	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.25	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.25	–	dB
THD	total harmonic distortion at LN	V_{LN} = 1.4 V (RMS)	–	–	2	%
$V_{HFTX(rms)}$	maximum input voltage at HFTX (RMS value)	I_{line} = 70 mA; THD = 2%	–	95	–	mV
$V_{no(LN)}$	noise output voltage at pin LN; pin HFTX shorted to GND through 200 Ω in series with 10 μF	psophometrically weighted (p53 curve)	–	–77.5	–	dBmp
$\Delta G_{v(mute)}$	gain reduction if not activated	HFC = LOW; $\overline{MUTT}$ = HIGH; $\overline{MUTR}$ = LOW; AUXC = HIGH	60	80	–	dB
MICROPHONE MONITORING ON TXOUT (PINS MIC+, MIC– AND TXOUT); note 1						
$G_{v(MIC-TXOUT)}$	voltage gain from pin MIC+/MIC– to TXOUT	V_{MIC} = 2 mV (RMS)	48.3	49.8	51.3	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.1	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.35	–	dB
RX amplifiers						
RX AMPLIFIERS USING IR (PINS IR AND RECO); note 1						
$G_{v(IR-RECO)}$	voltage gain from pin IR (referenced to LN) to RECO	V_{IR} = 15 mV (RMS)	28.7	29.7	30.7	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 30 to 3400 Hz	–	±0.25	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.3	–	dB
$V_{IR(rms)(max)}$	maximum input voltage on IR (referenced to LN) (RMS value)	I_{line} = 70 mA; THD = 2%	–	50	–	mV
$V_{RECO(rms)(max)}$	maximum output voltage on RECO (RMS value)	THD = 2%	0.75	0.9	–	V
$V_{no(RECO)(rms)}$	noise output voltage at pin RECO; pin IR is an open circuit (RMS value)	psophometrically weighted (p53 curve)	–	–88	–	dBVp

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$\Delta G_{v(mute)}$	gain reduction if not activated	$\overline{HFC}$ = LOW; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = LOW; AUXC = LOW	60	80	–	dB
RX EARPIECE AMPLIFIER (PINS GARX AND QR); note 1						
$\Delta G_{v(RECO-QR)}$	gain voltage range between pins RECO and QR		–3	–	+15	dB
$V_{QR(rms)(max)}$	maximum output voltage on QR (RMS value)	sine wave drive; R_L = 150 Ω; THD < 2%	0.75	0.9	–	V
$V_{no(QR)(rms)}$	noise output voltage at pin QR; pin IR is an open-circuit (RMS value)	$G_{v(QR)}$ = 0 dB; psophometrically weighted (p53 curve)	–	–88	–	dBVp
RX AMPLIFIER USING RAUX (PINS RAUX AND RECO); note 1						
$G_{v(RAUX-RECO)}$	voltage gain from pin RAUX to RECO	V_{RAUX} = 0.4 V (RMS)	–3.7	–2.4	–1.1	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.25	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.25	–	dB
$V_{RAUX(rms)}$	maximum input voltage on RAUX (RMS value)	THD = 2%	–	0.95	–	V
$V_{no(RECO)(rms)}$	noise output voltage at pin RECO; pin RAUX shorted to GND through 200 Ω in series with 10 μF (RMS value)	psophometrically weighted (p53 curve)	–	–100	–	dBVp
$\Delta G_{v(mute)}$	gain reduction if not activated	$\overline{HFC}$ = LOW; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = LOW; AUXC = LOW	60	80	–	dB
Auxiliary amplifiers using AUXO						
TX AUXILIARY AMPLIFIER USING MIC+ AND MIC– (PINS MIC+, MIC– AND AUXO); note 1						
$G_{v(MIC-AUXO)}$	voltage gain from pin MIC+/MIC– to AUXO	V_{MIC} = 10 mV (RMS)	24.2	25.5	26.8	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.1	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25°C	T_{amb} = –25 to +75 °C	–	±0.3	–	dB
$V_{MIC(rms)}$	maximum input voltage on MIC+/MIC– (RMS value)	THD = 2%	–	16	–	mV
$V_{no(AUXO)}$	noise output voltage at pin AUXO; pins MIC+/MIC– shorted to GNDTX through 200 Ω in series with 10 μF (RMS value)	psophometrically weighted (p53 curve)	–	–91	–	dBVp

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
TX AUXILIARY AMPLIFIER USING HFTX (PINS HFTX AND AUXO); note 1						
$G_{v(HFTX-AUXO)}$	voltage gain from pin HFTX to AUXO	V_{HFTX} = 100 mV (RMS)	14.2	15.2	16.2	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.1	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.1	–	dB
$V_{AUXO(rms)}$	maximum output voltage on AUXO (RMS value)	THD = 2%	0.8	0.9	–	V
$V_{no(AUXO)(rms)}$	noise output voltage at pin AUXO; pin HFTX shorted to GND through 200 Ω in series with 10 μF (RMS value)	psophometrically weighted (p53 curve)	–	–91.5	–	dBVp
$\Delta G_{v(mute)}$	gain reduction if not activated	$\overline{HFC}$ = LOW; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = HIGH; AUXC = LOW	60	80	–	dB
RX AMPLIFIER USING IR (PINS IR AND AUXO); note 1						
$G_{v(IR-AUXO)}$	voltage gain from pin IR (referred to LN) to AUXO	V_{IR} = 3 mV (RMS)	31.6	32.8	34	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.1	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.3	–	dB
$V_{AUXO(rms)}$	maximum output voltage on AUXO (RMS value)	THD = 2%	0.8	0.9	–	V
$V_{no(AUXO)(rms)}$	noise output voltage at pin AUXO; pin IR is an open circuit (RMS value)	psophometrically weighted (p53 curve)	–	–85	–	dBVp
$\Delta G_{v(mute)}$	gain reduction if not activated	$\overline{HFC}$ = HIGH; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = HIGH; AUXC = HIGH	60	80	–	dB
Automatic Gain Control (pin AGC)						
$\Delta G_{v(trx)}$	gain control range for transmit and receive amplifiers affected by the AGC; with respect to I_{line} = 15 mA	I_{line} = 70 mA; on $G_{v(MIC-LN)}$, $G_{v(IR-RECO)}$ and $G_{v(IR-AUXO)}$	5.45	6.45	7.45	dB
		I_{line} = 70 mA for other transmit and receive gains affected	5.8	6.8	7.8	
I_{start}	highest line current for maximum gain		–	23	–	mA
I_{stop}	lowest line current for maximum gain		–	57	–	mA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Logic inputs (pins HFC, AUXC, $\overline{\text{MUTT}}$ and $\overline{\text{MUTR}}$)						
V_{IL}	LOW-level input voltage		–0.4	–	0.3	V
V_{IH}	HIGH-level input voltage		1.8	–	V_{BB} + 0.4	V
I	input current	V_{BB} = 3 V				
	for pins HFC and AUXC		–	3	6	µA
	for pins $\overline{\text{MUTT}}$ and $\overline{\text{MUTR}}$		–	–2.5	–6	µA
Handsfree						
HF MICROPHONE AMPLIFIER (PINS TXIN, TXOUT AND GATX); note 1						
$G_{v(TXIN-TXOUT)}$	voltage gain from pin TXIN to TXOUT	V_{TXIN} = 8 mV (RMS); R_{GATX} = 30.1 kΩ	12.7	15.2	17.7	dB
ΔG_v	voltage gain adjustment with R_{GATX}		–15	–	+16	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.1	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.15	–	dB
$V_{no(TXOUT)(rms)}$	noise output voltage at pin TXOUT; pin TXIN is shorted through 200 Ω in series with 10 µF to GNDTX (RMS value)	psophometrically weighted (p53 curve)	–	–101	–	dBmp
$\Delta G_{v(mute)}$	gain reduction if not activated	HFC = HIGH; $\overline{\text{MUTT}}$ = LOW; $\overline{\text{MUTR}}$ = LOW; AUXC = LOW	60	80	–	dB
HF LOUDSPEAKER AMPLIFIER (PINS HFRX, LSAO, GALS AND VOL); note 1						
$G_{v(HFRX-LSAO)}$	voltage gain from pin HFRX to LSAO	V_{HFRX} = 20 mV (RMS); R_{GALS} = 255 kΩ	25.5	28	30.5	dB
ΔG_v	voltage gain adjustment with R_{GALS}		–28	–	+7	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.3	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.3	–	dB
$\Delta G_{v(vol)}$	voltage gain variation related to ΔR_{VOL} = 1.9 kΩ	when total attenuation does not exceed the switching range	–	–3	–	dB
$V_{HFRX(rms)(max)}$	maximum input voltage at pin HFRX (RMS value)	I_{line} = 70 mA R_{GALS} = 33 kΩ; for 2% THD in the input stage	–	580	–	mV
$V_{no(LSAO)(rms)}$	noise output voltage at pin LSAO; pin HFRX is open circuit (RMS value)	psophometrically weighted (p53 curve)	–	–79	–	dBVp

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{LSAO(rms)}$	output voltage (RMS value) without external supply on pin ESI	I_{BB} = 0 mA; I_{DD} = 1 mA				
		I_{line} = 18 mA	–	0.9	–	V
		I_{line} = 30 mA	–	1.3	–	V
		I_{line} > 50 mA	–	1.6	–	V
$I_{LSAO(max)}$	maximum output current at pin LSAO (peak value)		150	300	–	mA
$\Delta G_{v(mute)}$	gain reduction if not activated	HFC = HIGH; $\overline{MUTT}$ = HIGH; $\overline{MUTR}$ = HIGH; AUXC = HIGH	60	80	–	dB
DYNAMIC LIMITER (PINS LSAO AND DLC)						
t_{att}	attack time	when V_{HFRX} jumps from 20 mV to 20 mV + 10 dB	–	–	5	ms
		when V_{BB} jumps below $V_{BB(th)}$	–	1	–	ms
t_{rel}	release time	when V_{HFRX} jumps from 20 mV + 10 dB to 20 mV	–	100	–	ms
THD	total harmonic distortion at V_{HFRX} = 20 mV + 10 dB	$t > t_{att}$	–	0.1	2	%
$V_{BB(th)}$	V_{BB} limiter threshold		–	2.7	–	V
MUTE LOUDSPEAKER (PIN DLC)						
$V_{DLC(th)}$	threshold voltage required on pin DLC to obtain mute receive condition		–0.4	–	+0.2	V
$I_{DLC(th)}$	threshold current sourced by pin DLC in mute receive condition	V_{DLC} = 0.2 V	–	100	–	µA
$\Delta G_{vrx(mute)}$	voltage gain reduction in mute receive condition	V_{DLC} = 0.2 V	60	80	–	dB
RX AMPLIFIER USING HFRX (PINS HFRX AND AUXO); note 1						
$G_{v(HFRX-AUXO)}$	voltage gain from pin HFRX to AUXO	V_{HFRX} = 0.25 V (RMS)	1.2	3.7	6.2	dB
$\Delta G_{v(f)}$	gain variation with frequency referenced to 1 kHz	f = 300 to 3400 Hz	–	±0.1	–	dB
$\Delta G_{v(T)}$	gain variation with temperature referenced to 25 °C	T_{amb} = –25 to +75 °C	–	±0.4	–	dB
$V_{HFRX(rms)}$	maximum input voltage at pin HFRX (RMS value)	I_{line} = 70 mA; for 2% THD in the input stage	–	580	–	mV
$V_{no(AUXO)(rms)}$	noise output voltage at pin AUXO; pin HFRX is an open-circuit (RMS value)	psophometrically weighted (p53 curve)	–	–100	–	dBVp
$\Delta G_{v(mute)}$	gain reduction if not activated	HFC = LOW; $\overline{MUTT}$ = LOW; $\overline{MUTR}$ = HIGH; AUXC = LOW	60	80	–	dB

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
TX AND RX ENVELOPE AND NOISE DETECTORS (PINS TSEN, TENV, TNOI, RSEN, RENV AND RNOI)						
Preamplifiers						
$G_{v(TSEN)}$	voltage gain from pin TXIN to TSEN		–	40	–	dB
$G_{v(RSEN)}$	voltage gain from pin HFRX to RSEN		–	0	–	dB
Logarithmic compressor and sensitivity adjustment						
$\Delta V_{det(TSEN)}$	sensitivity detection on pin TSEN; voltage change on pin TENV when doubling the current from TSEN	I_{TSEN} = 0.8 to 160 μA	–	18	–	mV
$\Delta V_{det(RSEN)}$	sensitivity detection on pin RSEN; voltage change on pin RENV when doubling the current from RSEN	I_{RSEN} = 0.8 to 160 μA	–	18	–	mV
Signal envelope detectors						
$I_{source(ENV)}$	maximum current sourced from pin TENV or RENV		–	120	–	μA
$I_{sink(ENV)}$	maximum current sunk by pin TENV or RENV		–1.25	–1	–0.75	μA
ΔV_{ENV}	voltage difference between pins RENV and TENV	when 10 μA is sourced from both RSEN and TSEN; signal detectors tracking; note 2	–	±3	–	mV
Noise envelope detectors						
$I_{source(NOI)}$	maximum current sourced from pin TNOI or RNOI		0.75	1	1.25	μA
$I_{sink(NOI)}$	maximum current sunk by pin TNOI or RNOI	dial tone detector or TX level limiter not activated	–	–120	–	μA
ΔV_{NOI}	voltage difference between pins RNOI and TNOI	when 5 μA is sourced from both RSEN and TSEN; noise detectors tracking; note 2	–	±3	–	mV
DIAL TONE DETECTOR						
$V_{HFRX(th)(rms)}$	threshold level at pin HFRX (RMS value)	R_{RSEN} = 10 kΩ	–	25	–	mV
TX LEVEL LIMITER						
$V_{TXIN(th)(rms)}$	threshold level at pin TXIN (RMS value)	R_{TSEN} = 10 kΩ	–	0.75	–	mV

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
DECISION LOGIC (PINS IDT AND SWT)						
Signal recognition						
$\Delta V_{Srx(th)}$	threshold voltage between pins RENV and RNOI to switch-over from receive to Idle mode	$V_{HFRX} < V_{HFRX(th)}$; note 3	–	13	–	mV
$\Delta V_{Stx(th)}$	threshold voltage between pins TENV and TNOI to switch-over from transmit to Idle mode	$V_{TXIN} < V_{TXIN(th)}$; note 3	–	13	–	mV
Switch-over						
$I_{source(SWT)}$	current sourced from pin SWT when switching to receive mode		7.5	10.0	12.5	µA
$I_{sink(SWT)}$	current sunk by pin SWT when switching to transmit mode		–12.5	–10.0	–7.5	µA
$I_{idle(SWT)}$	current sourced from pin SWT in Idle mode		–	0	–	µA
VOICE SWITCH (PINS STAB AND SWR)						
SWRA	switching range		–	40	–	dB
ΔSWRA	switching range adjustment	with R_{SWR} referenced to 365 kΩ	–40	–	+12	dB
$\lvert\Delta G_v\rvert$	voltage gain variation from transmit or receive mode to Idle mode		–	20	–	dB
G_{trx}	gain tracking ($G_{vtx} + G_{vrx}$) during switching, referenced to Idle mode		–	0.5	–	dB

Notes

1. When the channel is enabled according to Table 2.
2. Corresponds to ±1 dB tracking.
3. Corresponds to 4.3 dB noise/speech recognition level.

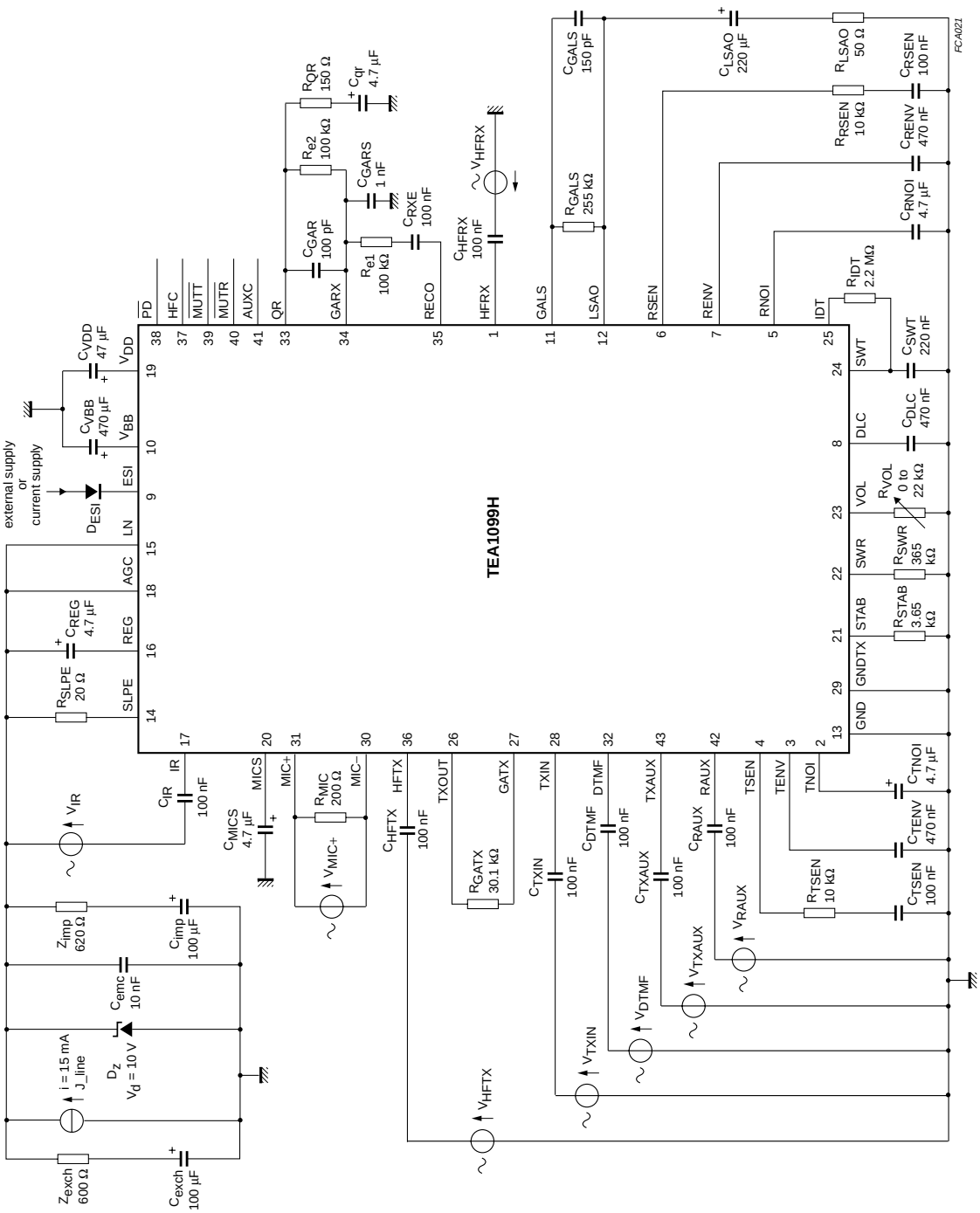


Fig.15 Test circuit.

APPLICATION INFORMATION

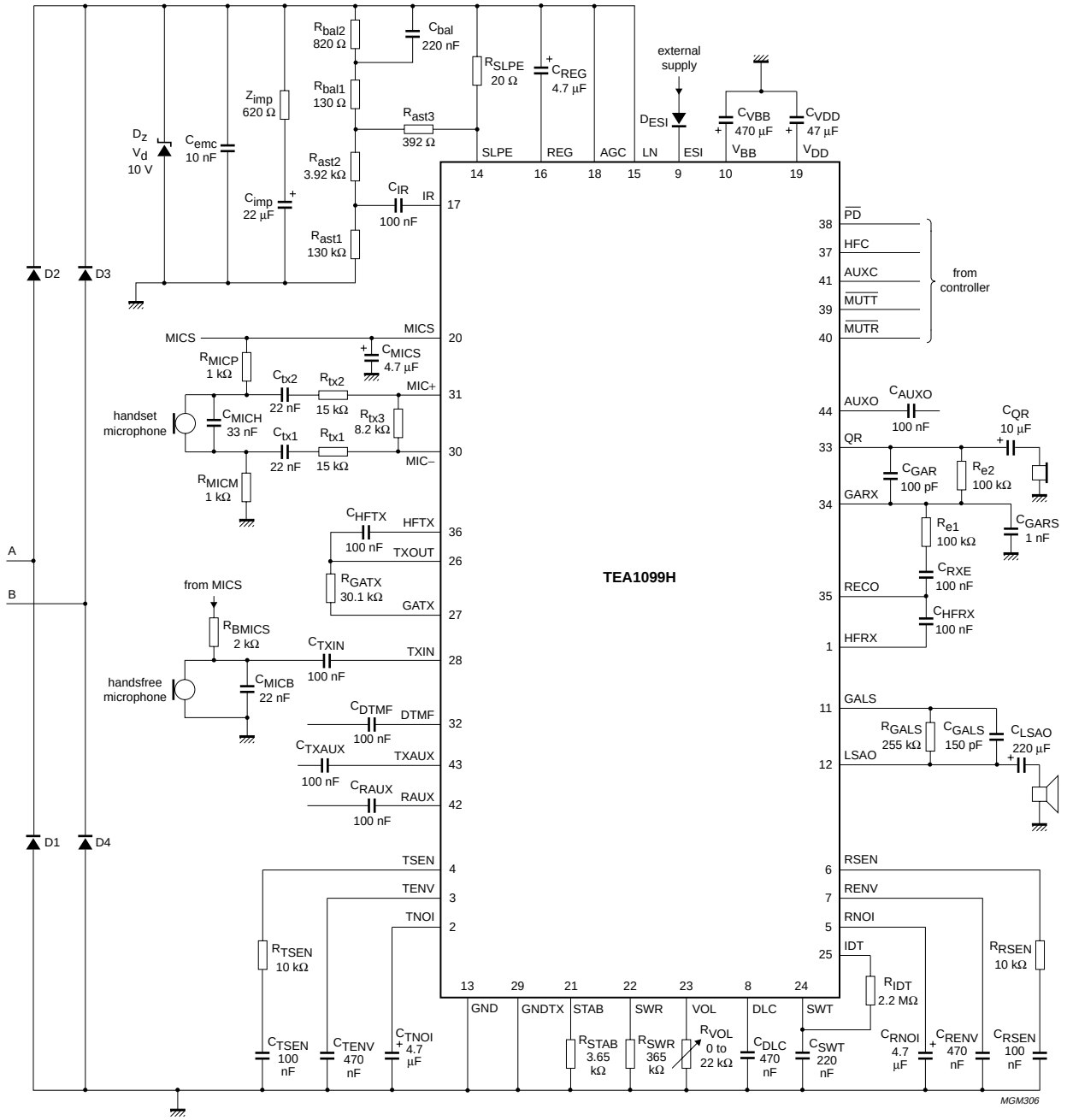
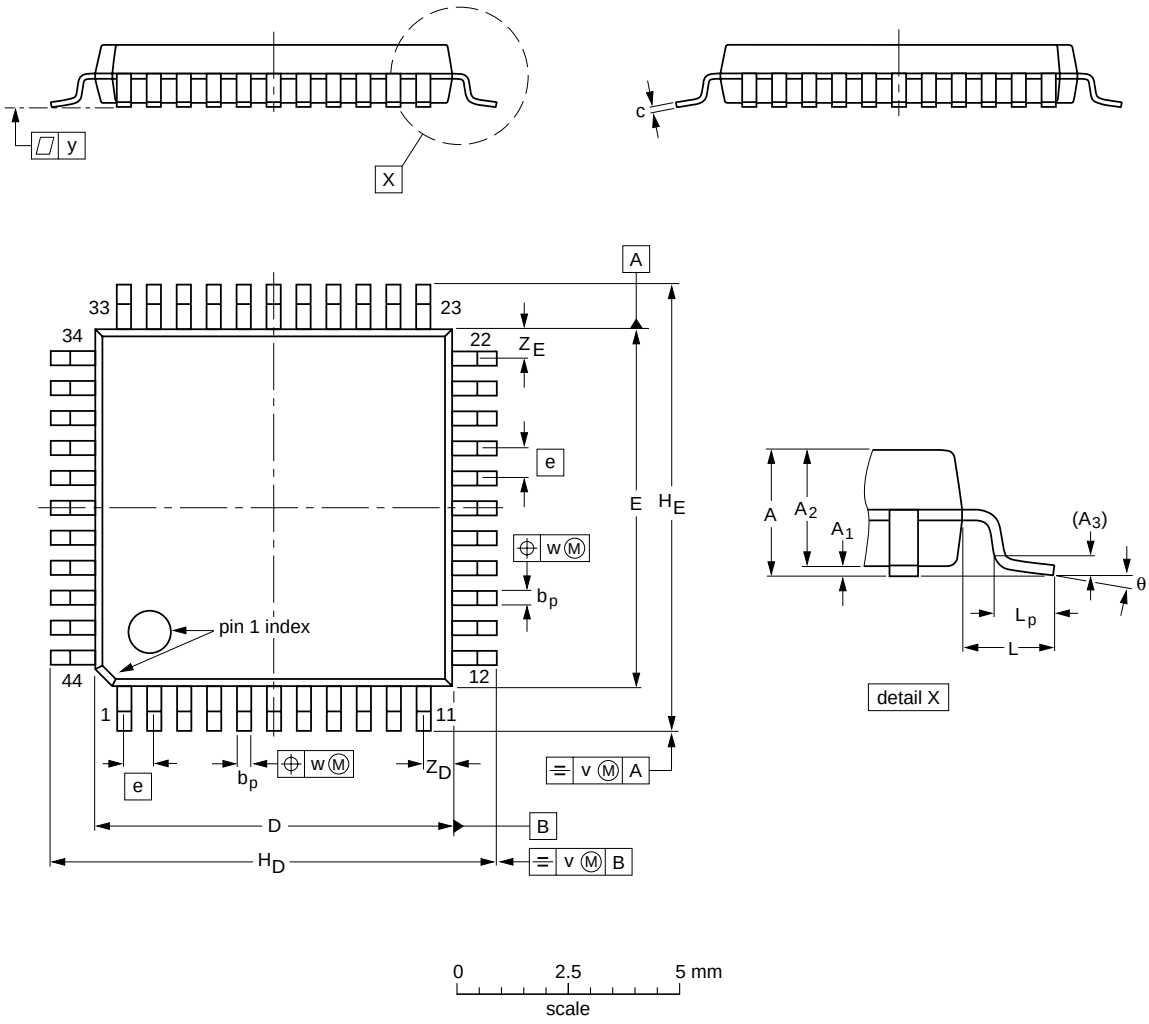


Fig.16 Basic application diagram.

PACKAGE OUTLINE

QFP44: plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 x 10 x 1.75 mm **SOT307-2**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_D	H_E	L	L_p	v	w	y	$Z_D^{(1)}$	$Z_E^{(1)}$	θ
mm	2.10	0.25 0.05	1.85 1.65	0.25	0.40 0.20	0.25 0.14	10.1 9.9	10.1 9.9	0.8	12.9 12.3	12.9 12.3	1.3	0.95 0.55	0.15	0.15	0.1	1.2 0.8	1.2 0.8	10^o 0^o

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT307-2						~~95-02-04~~ 97-08-01

SOLDERING

Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferable be kept below 230 °C.

Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
  - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

  The footprint must incorporate solder thieves at the downstream end.
- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.
A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

Suitability of surface mount IC packages for wave and reflow soldering methods

PACKAGE	SOLDERING METHOD	
	WAVE	REFLOW(1)
BGA, SQFP	not suitable	suitable
HLQFP, HSQFP, HSOP, HTSSOP, SMS	not suitable(2)	suitable
PLCC(3), SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended(3)(4)	suitable
SSOP, TSSOP, VSO	not recommended(5)	suitable

Notes

1. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *"Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods"*.
2. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
3. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
4. Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
5. Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

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